Forest Research 76

Ontario

Ministry of Natural Resources

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Minister

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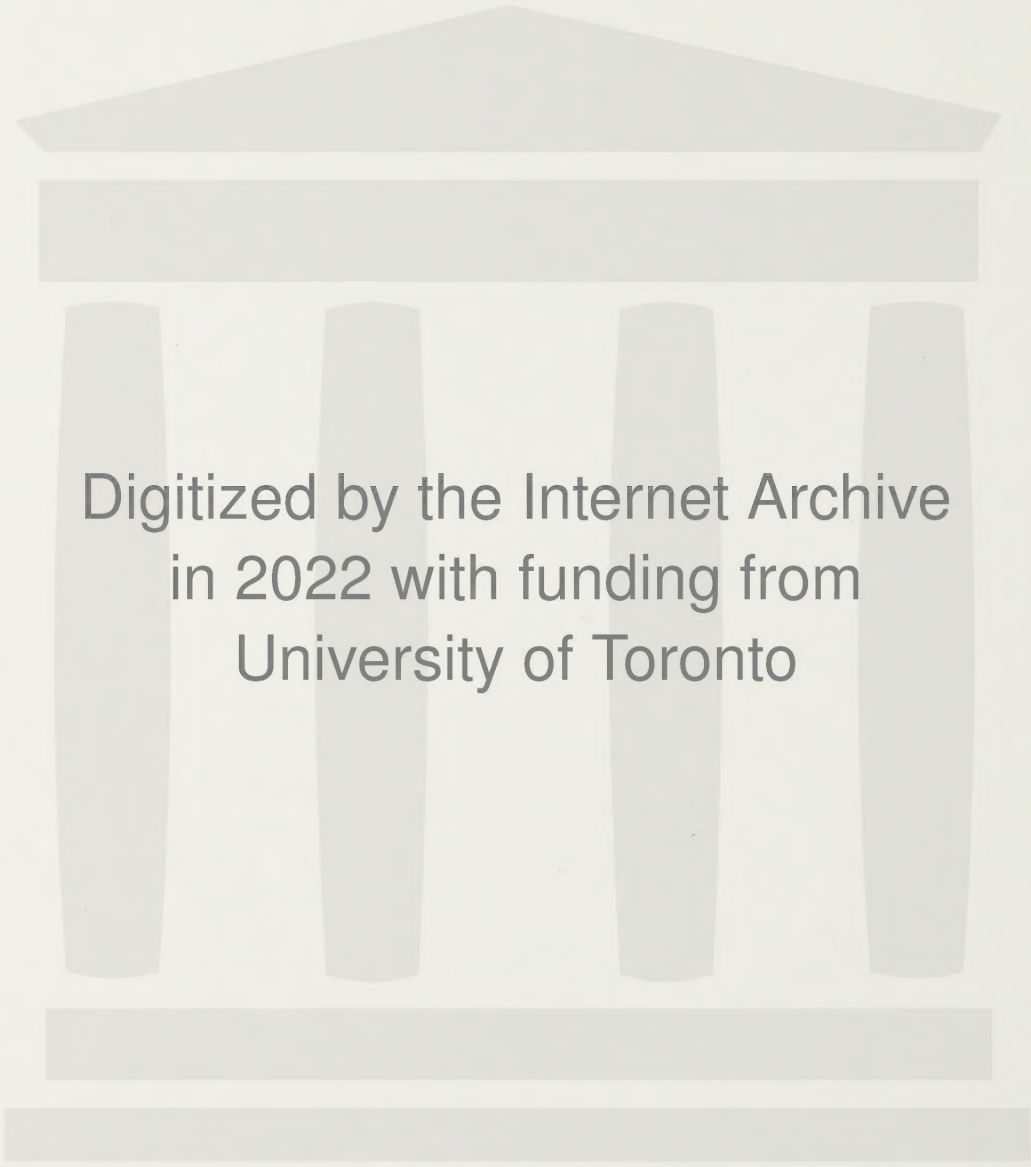
Deputy Minister



FOREST RESEARCH 76

ANNUAL PROGRAM REPORT OF THE FOREST RESEARCH BRANCH

JANUARY 1 TO DECEMBER 31, 1976

Division of Forests

Ministry of Natural Resources

Ontario

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CONTENTS CONTENTS CONTENTS CONTENTS CONTENTS CONTENTS CONTENTS CONTENTS

See reply card inside back cover for Requests & Comments

INTRODUCTION INTRODUCTION INTRODUCTION INTRODUCTION INTRODUCTION INTRO-

The main research effort of the Forest Research Branch is in the biological and ecological aspects of forest production. In this year's capsule of work undertaken you will find not only broad general studies, but also detailed sophisticated work. All are related through sometimes complex pathways to the major concern: improvement of forest production.

A ready overview of the emphasis and progress of research programs may be obtained by reading the brief introduction to each chapter in this report.

Good progress was made towards the implementation of research results in management programs. Through the contacts in the Tree Improvement Committee, gains have been made in better seed identification methods; seed collection methods have been discussed and coordination of research and management programs has greatly improved. The somewhat informal tree marking course is being developed into a certificate course. Two soil courses were given in two Regions and a third Region approached us to assist in the development of a program for a region-wide site survey. Participation by Districts in so-called cooperative research projects is gratefully acknowledged. Such activities and interest benefit both management and research.

Through the Canada-Ontario Joint Forest Research Committee (COJFRC) liaison is being maintained with the Great Lakes Forest Research Centre (GLFRC) and the Petawawa Forest Experiment Station of the Canadian Forestry Service. The Committee meets twice a year to coordinate the planning and reviewing of research programs and to coordinate effective communication of research results to forest managers and administration. During the past year COJFRC sponsored the Plantation Establishment Symposium at Kirkland Lake where 149 persons participated. Also, a group of eight researchers, four from the GLFRC and four from the Forest Research Branch, made a tour to the four southern administrative regions of the Province to present to managers overviews and details of some research programs of particular relevance to those regions.

In addition to providing direct answers to operational problems, the Forest Research Branch is aware that real progress in management

is supported by innovative research which increases our understanding of systems and relationships so that we can take effective action and circumvent problems. Some of the present applications by management of research results -- such as the use of fast-growing hybrid poplars, marking tolerant hardwoods for cutting, prescribed burning, site classification and mapping - are possible because forward-looking research which was started one or more decades ago anticipated the need for certain kinds of knowledge and information. We sometimes wish we had started more of that type of research and we should be prepared now to continue the long term view. Positive participation and interest by managers and administrators for this approach may lead to substantial gains in forest management in this province.

You are invited to write or telephone research staff for further information or for making comments or suggestions.

Organization

Forest Research is a Branch within the Division of Forests, Ministry of Natural Resources. The headquarters of the Forest Research Branch is at the research station at Maple, located approximately 15 km north of Toronto. A tree breeding nursery and an arboretum, started in the early 1940's, are present at Maple, along with greenhouse, laboratory, office and workshop space.

Some 20 forest scientists are located at Maple with 15 technical support staff and 6 managerial and secretarial staff. Administratively, research units are: Tree Biology, Tree Breeding, Seed, Tree Nutrition, Site, Mensuration, Biomathematics, Southern Ontario Silviculture, Development and Mechanical.

Research staff are located also in field units at Midhurst, Dorset, Sault Ste. Marie and Thunder Bay for a further 7 forest scientists, 5 technical support staff and 4 managerial and secretarial staff.

Although laboratory and other investigations are centred at Maple and at the field unit offices, studies are conducted by the Forest Research Branch throughout the Province.

Research staff

Don Burton retired at the end of the year as Director, a position he had held for 4 years. Previous to that he was a successful researcher, particularly in yellow birch regeneration, and a research supervisor. Dr Dys Burger was appointed as Acting Director. George Buchert joined the staff in July to undertake work in improvement and breeding of the hard pines. Antonio (Tony) Citro was appointed leader of the Mechanical Unit and Dr David Fayle returned from his teaching sojourn at the University of New Brunswick.

Maple, Ontario LOJ 1E0 Telephone: (416) 832-2261

Burton, D. H.	BScF	Director
Anderson, H. W.	BScF, MScF	Tree biology: Hardwood quality. Chemotaxonomy
Beckwith, A. F.	BScF, MScF	Yield tables
Buchert, G. P.	BSc, MSc	Tree breeding: Hard pines
Burger, D.	AgrEng(For), PhD	Site: Classification. Nutrients (Acting Director)
Citro, A. L. M.	BScF	Mechanical research
Fayle, D. C. F.	BScF, DipFor, PhD	Tree biology: Root development
Glerum, C.	BScF, MScF	Tree biology: Physiology
Jaciw, P.	BScF	Hardwood silviculture in southern Ontario: Upland sites
Kim, Y-T.	BSc, MSc	Foliar analysis
Larsson, H. C.	BSA, BScF, MScF	Hardwood silviculture in southern Ontario: Lowland sites. Multi-purpose trees and shrubs
Leech, R. H.	BScF, MScF	Tree nutrition
Pierpoint, G.	BScF, MScF	Site: Moisture
Rauter, R. M.	BScF, MScF	Tree breeding: Spruce and larch
Raymond, F. L.	BS, AM, PhD	Data analysis and model building
Sinclair, G. A.	BScF, MF	Site: Hybrid poplar site/growth relations
Skeates, D. A.	BScF, MScF	Tree seed
Stroempl, G.	DiplForstwirt	Silvicultural aspects of mensuration
Williamson, V. H. H.		Development of equipment and techniques
Zsuffa, L.	BScF, PhD	Tree breeding: Poplar. Soft pines

Midhurst, Ontario LOL 1X0 Telephone: (705) 726-7640

Mullin, R. E.	BScF, MScF, PhD	Nursery stock

Box 190, Dorset, Ontario POA 1EO Telephone: (705) 766-2671

McLean, M. M.	BScF	Management of tolerant hardwood forest

c/o Box 490, Sault Ste. Marie, Ontario P6A 5M7 Telephone: (705) 949-9461

Gordon, A. G.	BScF, PhD	Ecological productivity and genecology of spruce

Box 2960, Thunder Bay "P", Ontario P7B 5G5 Telephone: (807) 767-1607

Lyon, N. F.	BScF	Supervision of research in silviculture of the spruce-fir-aspen forest
Kemperman, J. A.	BS, MF	Silviculture of spruce-fir-aspen forest: Aspen
Lehela, A.	BScF, MScF	Silviculture of spruce-fir-aspen forest: Balsam fir
McClain, K.	BScF, MScF	Silviculture of spruce-fir-aspen forest: Black spruce

Support services Photographic (Jean Robinson) and drafting (J. Hall) services, located at Maple and administered by the Forest Research Branch and Fish and Wildlife Branch respectively, are available to all staff. The Research Library of the Ministry, which is an essential adjunct for research, is also situated at Maple.

NEW PUBLICATIONS NEW PUBLICATIONS NEW PUBLICATIONS NEW PUBLICATIONS NEW

Publication in journals, proceedings of meetings, etc. and in Forest Research Branch reports constitute the formal, written communication of research results. This information, through libraries and secondary information and abstracting services, becomes available to a wide range of users, now and in the future.

Reprints or copies of the following publications may be obtained by circling the appropriate numbers on the addressed, tear sheet at the back of this report, or by writing directly to the individual authors:

1. BURGER, D. 1976. The concept of ecosystem region in forest site classification, p. 213-218. In 16th IUFRO Congress, Oslo, Norway, Division I Proceedings.
   Forest site regions as recognized in Ontario are extended to include Michigan, Wisconsin and Minnesota. A preliminary map and selected reference points are given. Relevance to forest management is stressed.

2. FAYLE, D.C.F. 1976. Stem sway affects ring width and compression wood formation in exposed root bases. Forest Science 22(2): 193-194.
   A relationship between radial growth, mechanical stress and formation of compression wood is suggested.

3. FAYLE, D.C.F. 1976. "Take it off!" The Forestry Chronicle 52(6): 265.
   Points out how stem analysis techniques could be a useful diagnostic tool to the silviculturist.

4. GLERUM, C. 1976. Frost hardiness in forest trees, p. 403-420. In M.G.R. Cannell and F.T. Last (Ed.). Tree physiology and yield improvement. Academic Press, London and New York.
   A critical review of the more important aspects of frost hardiness vis à vis dormancy and tree improvement.

5. GLERUM, C. and R.E. MULLIN. 1976. Some biological aspects of nursery stock production, p. 764-772. In 16th IUFRO Congress, Oslo, Norway, Division I Proceedings.
   Reviews some of the more important biological aspects in nursery stock production, in particular the need for continuous quality control of nursery stock as related to field performances.

6. GORDON, A.G. 1975. Productivity and nutrient cycling by site in spruce forest ecosystems, p. 119-126. In T.W.M. Cameron and L.W. Billingsley (Ed.). Energy flow--Its biological dimensions. A summary of the IBP in Canada 1964-74. CCIBP, Royal Society of Canada, Ottawa.
   Discusses some results concerning the cycling of N, P and K in spruce forests on 3 moisture sites.

7. GORDON, A.G. 1976. The taxonomy and genetics of *Picea rubens* and its relationship to *Picea mariana*. Can. J. Bot. 54(9): 781-813.
   Reports on the variation within red spruce and the nature and extent of hybridization with black spruce.

8. KEMPERMAN, J.A. (and B.V. BARNES). 1976. Clone size in American aspens. Canadian Journal of Botany 54(22): 2603-2607.
The aspen clone, not the individual aspen tree, is the key element in sound management of this species.

9. KEMPERMAN, J.A., N.F. LYON (and S. NAVRATIL). 1976. Incidence and volume of defect in second growth aspen stands in northern Ontario. Ontario Ministry of Natural Resources, Forest Research Report No. 102. 24 p.
The development of these second growth stands will probably not be seriously limited by defect until they are at least 40-60 years old.

10. McCLAIN, K.M. (and K.A. ARMSON). 1976. Effect of water supply, nitrogen and seedbed density on white spruce seedling growth. Soil Science Society of America Proceedings 40(3):443-446.
Seedbed densities and N fertilization can be varied simultaneously or independently to fit stock to a particular growth pattern.

11. MULLIN, R.E. 1976. Underplanting tests with red and white pine in southern Ontario. Ontario Ministry of Natural Resources, Forest Research Note No. 2. 4 p.
The use of 2+0 red and white pine in underplanting was found questionable, and the Sandvik hoe was found less satisfactory than shovel or spade in the planting procedure.

12. MULLIN, R.E. (and J.D. PARKER). 1976. Provisional guidelines for fall lifting for frozen overwinter storage of nursery stock. The Forestry Chronicle 52(1): 22-25.
The paper introduces degree-hardening-days, D-H-D, i.e. cumulative daily differences below 50°F for soil temperature at 15 cm depth, as a possible criterion of stock readiness for storage (white spruce 200, white pine 225, red pine 300, jack pine 375).

13. MULLIN, R.E. (and L. FORCIER). 1976. Effect of lifting and planting dates on survival and growth of spring stored nursery stock. Ontario Ministry of Natural Resources, Forest Research Note No. 3. 4 p.
Tests showed that successful spring frozen storage of white spruce, black spruce and jack pine depended on early lifting, and that properly lifted and stored stock was better for late planting than was fresh stock.

14. RAUTER, R.M. 1976. Genetic improvement of spruce in Ontario, 1973-74, p. 85-88. In Proceedings 15th Meeting Canadian Tree Improvement Association, Petawawa, Ontario, Aug. 18-22, 1975. Part 1.
Summarizes the work undertaken in 1973-74 on white and black spruce.

15. STROEMPL, G. 1976. Peat wedges aid seedling establishment on shallow soil. The Forestry Chronicle 52(1): 47-51.
Discusses a planting method for sites with serious moisture deficits.

16. ZSUFFA, L. 1975. Some problems and aspects of breeding for pest resistance. Special paper, Second World Technical Consultation on Forest Diseases and Insects, New Delhi, India, April 7-12, 1975.

FAO/IUFRO/DI/75: 10-30. 11 p. (mimeo)
A discussion of research areas and methods important for effective breeding.

17. ZSUFFA, L. 1976. Poplar and pine breeding in 1973 and 1974, p. 89-95. In Proceedings 15th Meeting Canadian Tree Improvement Association, Petawawa, August 18-22, 1975. Part 1.
A summary of activities and results.

18. ZSUFFA, L. 1976. The features and prospects of poplar breeding in Ontario, Canada. Die Holzzucht 30(1): 37-40. (In German, with English summary.)
A discussion of poplar breeding needs--a summary of activities, and an outline of results.

19. ZSUFFA, L. (and R. CALVERT). 1976. Selecting shade trees for urban Canada, p. 286-292. In J.W. Andresen (Ed.). Trees and forests for human settlements. Centre for Urban Forestry Studies, University of Toronto.
A discussion of selection criteria and a summary of activities and results.

20. ZSUFFA, L. and G.H. SAUL. 1976. The rooting ability of winter stored and freshly planted cuttings of *Leuce* Duby (aspen) hybrid clones. Ontario Ministry of Natural Resources, Forest Research Note No. 4, 4 p.
Properly winter-stored cuttings root similarly to the freshly planted ones.

Reprints of the following reports given at the Plantation Establishment Symposium, Kirkland Lake, September 1976, are available from the Great Lakes Forest Research Centre, Canadian Forestry Service, P.O. Box 490, Sault Ste. Marie, Ont. P6A 5M7:

GLERUM, C. Determination of the readiness of coniferous seedlings for overwinter cold storage. 7 p.
Reports on the progress of using electrical impedance to predict fall lifting dates for overwinter cold storage.

McCLAIN, K.M. and H.W. ANDERSON. The improvement of regeneration through the integration of nursery stock monitoring and plantation quality assessments. 5 p.
The present state of regeneration success in Ontario is discussed and the integration of nursery stock monitoring and plantation performance records is suggested as a means of securing better pre- and post-planning performance of nursery stock.

MULLIN, R.E. Practical guidelines to nursery stock quality. 11 p.
Studies of nursery stock over many years showed that imbalance of stock (high top-root ratios) was common and increasing. A quick test method for top-root ratio determination by planters (water displacement) is given as well as a set of standards for several species.

NEW PUBLICATIONS NEW PUBLICATIONS NEW PUBLICATIONS NEW PUBLICATIONS

PIERPOINT, G. Soil is what you plant in. 2 p.
Comments on the general influence of certain soil and site factors on establishment of planted seedlings, and how the management forester might help in providing favourable conditions.

A mimeo of the following report, given at the Forest Nursery Short Course, University of New Brunswick, October 1976, is available from the UNB Department of Extension and Summer Sessions, Fredericton, N.B. E3B 5A3:

MULLIN, R.E. Arriving alive and well. 37 p.
A comprehensive review of the author's work in relation to nursery stock quality, lifting and storage, shipping and handling, and planting.

ENHANCING STOCK PRODUCTION AND PERFORMANCE ENHANCING STOCK PRODUCTION

Research into various aspects of the production and performance of stock used for the artificial regeneration of Ontario's forests is a major program. Studies range from obtaining and germinating seed to maximize returns, through manipulation of seedbed treatments and storage methods, to outplanting and understanding the processes that influence the performance of the stock. Related work is also presented in later chapters.

Seed collection

A cherry-picker machine provided good access, up to 14 m, to cone-bearing tops of white spruce (*Picea glauca*) on accessible sites where heavy equipment can be driven close to trees. Two men are required in the operation with only one picking from the bucket. Climbing, however, was at least as fast a means of reaching the top and the number of climbers is not limited by capital investment. Climbing was considered faster, more economical, and more practical in terms of a range of locations and tree heights. The climbing techniques used have now been demonstrated in most major white spruce collecting districts. (Skeates)

Pregermination of seed

For seed lots of poor germinative capacity or slow rate of germination, precision sowing techniques with pregerminated seed will contribute to early uniform growth and uniform spacing of plants. For greenhouse systems, such as spruce in containers and germinant transplants, a culling stage will ensure full stocking of established plants. For seedling development, such as jack pine (*Pinus banksiana*) in containers and seedling spruce, pregermination has a place with precision sown seed in sphagnum "ropes" laid directly onto peat-covered nursery beds under growth shelters. In each case modified climatic conditions are necessary for optimum early development of germinants.

A Dewa block machine, developed for agricultural and horticultural production in the Netherlands, was modified to dibble each soil cube for planting germination plugs. The machine was used in pilot pregermination projects in the spring of 1976.

Development work is continuing to automate the entire process from cutting germination plugs, seeding, planting of germinants, to transplanting soil cubes into nursery beds. The feature of greatest significance to management is automated transplanting. The technique has potential application for production of 2-year-old black spruce (*Picea mariana*) transplants and white spruce seedlings. (Skeates and Williamson)

"Cigarette" containers

Sphagnum cigarettes 2 cm in diameter developed at Kemptville nursery were tested at Maple. Early observations indicate problems with moisture absorption by the dry peat moss, and early deterioration of the cellulose fibre used. Work is continuing to develop a more suitable growing media and coverings. (Skeates)

Pilot studies initiated

A study using black spruce seed, pregerminated in sphagnum plugs at varying times through the 1975 season, planted in Dewa blocks, grown in greenhouses and transplanted into Orono nursery was assessed in the fall of 1976. Seed sown from February to early April produced 2-year-old trees in excess of 3 g total dry weight, 4 mm root collar diameter and 20 cm tall with shoot-root ratios of 1.9 to 2.1. Pilot operations of the system were started this year at several nurseries, using tamarack (*Larix laricina*), black spruce and white spruce. (Skeates)

New growth shelter developed

For a number of years shelters built over nursery beds have been used to promote germination and growth of seedlings. The most commonly used shelters are constructed of metal arches spanning the beds with a polyethylene film drawn over them. Such shelters are generally difficult to ventilate and require some means to protect the seedlings from sunburning.

An experimental design has now been completed for a shelter made with a new form of plastic material, recently introduced to the Canadian market. The material is manufactured from

polyproplene/ethylene resins in an extruded, translucent, corrugated sheet 120 cm x 240 cm. The sheets (non-pigmented) are ultraviolet stabilized, have a light transmission index of 75%, and an estimated life expectancy in use of 4-5 years.

The shelter is a peaked roof design with 30-cm high side walls that include a simple ventilating system, an overall height of 89 cm and a width sufficient to span a standard 110-cm wide nursery bed. It is self-supporting and strong enough to withstand high winds. A complete shelter is made up of 1.2-m long modules that can be joined together.

Five shelters, each 30 m long, have been constructed at Maple for field testing in 1977. Three have been supplied to field nurseries and two will be erected at the Southern Research Station, Maple. An additional 150-m long shelter has been made at Dryden nursery in the Northwestern Region and will be tested there. (Williamson)

Seedbed density and nutrition

The nursery phase of an investigation to test the effects of intensive nursery soil management on field survival and growth of white spruce seedlings was completed in the fall of 1976 at the Thunder Bay Forest Station. The stock (2+0, 3+0) was managed at strict density levels and regimes of N nutrition. Growth was monitored for each treatment level and analysed to develop growth progression curves for stock within the range of treatments applied. Field testing will be initiated in the spring of 1977 and will include a value test of fall versus spring lifting. Similar work was initiated using 2+0 black spruce and will continue during 1977. (McClain)

A series of experiments at Midhurst to examine seedbed densities (160 vs 320 trees/m^2) and fertilizer levels (control, normal or double) for top dressing during 2+0 and 3+0 years, was analysed. For the 3 species used -- white spruce, white pine (*Pinus strobus*) and red pine (*Pinus resinosa*) -- reduction of seedbed density to the lower level increased the seedling size (stem diameter and oven-dry weight) in the nursery and gave increased performance after outplanting. Reduction

of all 3+0 seedbeds to this level is recommended for these species. The normal fertilizer practice of top dressing was found ineffective or even damaging for red and white pine, although slightly beneficial for white spruce. Continuous planting of statistical test plots will be required to examine the effectiveness of this and other nursery procedures. (Mullin)

Storage

A study of water and clay dipping of roots of white pine showed that, based on second-year measurements, neither treatment was of any benefit for stock being placed in overwinter storage. A similar test on other species showed no benefit from a dip of Agricol for either storage or fresh planting.

Several experiments were planted in the spring of 1976 including: a field test of 'polybins' for overwinter, frozen-storage (red pine at Coldwater); a planting check on the use of growth chambers to test quality of stock in storage (red pine and white spruce at Midhurst); a test of 'rate of freezing' for storage in various comparison of storage containers for 1+0 greenhouse stock used for transplanting (black spruce at Swastika); a comparison of kraft and 'polybin' containers for 3+0 and 1½+1½ shipping stock (black spruce at Swastika); and a test of spring frozen storage regulated by degree-days for time of lifting (black spruce and jack pine at Swastika).

Other experiments on storage were begun in the fall of 1976 and placed in storage for planting-out in 1977. These include tests to examine the location and amounts of moss in the containers used for storage and for fresh planting, and tests of root pruning before storage. A small test has been started on frozen storage requirements for European larch (*Larix europea*) and tamarack. (Mullin)

Extension of planting season for black spruce

Field research initiated in 1975 to document survival and current annual increment of spring lifted and stored, and fresh lifted black spruce seedling and transplant stock at

bi-monthly intervals throughout the frost free period was continued during 1976. The 1975 plantations were measured in the fall of 1976. For the fresh and stored transplant stock survival was consistently high (95%+) up until late August, after which survival of the stored material decreased dramatically with further deferment of planting. Similar trends were noted for the seedling stock. Current annual increments showed dramatic differences. Height increment in 1976 for stored transplant stock was greater than that for the fresh transplant stock up until the end of July, after which growth of the fresh stock gradually increased above that of the stored transplant until the last planting in October. No height growth advantage of either the stored or fresh seedling stock was evident to the end of July; afterwards, however, height growth of the latter gradually increased with the later plantings. Although only based on one year's data from which only tenuous conclusions can be made, the results indicate that spring lifted and stored black spruce transplant stock (i.e. $1\frac{1}{2}+1\frac{1}{2}$) will outperform fresh lifted transplant stock up until the end of July, after which the reverse would hold. It follows therefore that if the best alternative for survival and growth is desirous the use of stored and fresh transplant stock is recommended over stored and fresh seedling stock. (McClain)

Poor performance of outplanted red pine

The study initiated last year to elucidate the problem of poor survival and abnormal growth of outplanted red pine nursery stock was continued. This year, an outplanting experiment was established to test whether the nursery stock quality or the typical field handling and planting method is a major factor causing the problem. With the cooperation of the district staff, test plantings were made twice during the spring season in six districts (Algonquin Park, Blind River, Cornwall, Huronia, Lindsay, Tweed). Half of the trees were handled from the nursery and planted by the Forest Research Branch crew with particular care, and the other half

were handled and planted by the district crews as part of their normal spring planting operation.

There was some indication from assessment of first-year performance that nursery stock quality may be depressing performance, but the evidence suggested overwhelmingly that the normal district handling and planting methods caused very highly significant reductions in performance. Survival was affected less than the growth and quality of terminal leader. Since the ability of a newly-planted seedling to compete in the field is dependent on its rapid establishment and early growth, these results are particularly important. Results will be published in a Forest Research Note in 1977.

A further comparison was made between stock from different nurseries. All seedlings were planted by the Forest Research Branch crew. No clear or major differences in first-year performance between stock of different nurseries was evident.

The monitoring of all these test plantings will continue. (Pierpoint and Glerum)

The possible role of nursery-applied herbicides affecting bud development is also being checked. As part of this study, samples of outplanted seedlings were analysed for herbicide residue by the Ministry of Agriculture and Food. Results to date, however, are inconclusive and further studies are being conducted. Although dacthal residues were found, no decision could be made as to lethal or growth-inhibiting levels. The findings will be published as a Forest Research Note in 1977. (Glerum)

Frost hardiness and dormancy

The dormancy of planting stock can be measured by electric impedance techniques. The testing of the electrical impedance prediction equations was continued at Orono Nursery. White spruce and white pine, lifted for cold storage on the predicted lifting dates of October 30 and November 13, 1975, were planted in the spring of 1976 and compared with freshly lifted trees. In the fall of 1976, survival was above 90% and no significant differences occurred in survival between control

and cold stored trees. Two lifting dates were predicted in the fall of 1976 and the predicted impedance values for the dates were again similar to the actual measurements on the lifting dates. (Glerum)

Role of food reserves

Analyses of radioactive carbon assimilation and depletion of food reserves in nursery stock suggest that food reserves play a minor role in wood formation in conifers and a major one in respiration. Reserves may possibly play a role in processes like dormancy and frost hardiness. Use of lipid or amino acid as a dormancy indicator appears to be promising. In seedlings, not only do the roots play an important role in the storage of reserves but so do the needles, particularly late in the season. This should be realized when monitoring reserves of seedlings during cold storage. (Glerum)

Ontario Tree Planter

After considerable modification, the Ontario Tree Planter was tested in the summer of 1976 on sites characterized by undulating topography, sandy loam soil, a fair amount of large sub-surface boulders (average diameter 60 cm) and exposed bedrock. Residual slash on the site was 18-36 m^3/ha, with branches or tops not exceeding 10 cm in diameter. Results were promising but not conclusive because testing was not extensive: machine availability, 80%; average and maximum numbers of trees planted per hour, 910 and 1200 respectively; trees well planted as a percent of total planted, 70-92% -- depending on site difficulty. (Citro)

IMPROVEMENT AND BREEDING OF SPRUCES AND PINES

The present emphasis in the spruces is on progeny tests to determine the genetic value of seed production areas and plus tree selections. The vegetative propagation program of rooting cuttings from nursery and plantation selections is well-established. Some work has been done on inter-specific hybridization and evaluation of other spruce species. Aspects related to breeding, such as induction of flowering, are being examined on a small scale. In pines, the development of blister rust resistant white pine continued and the groundwork was laid for extensive work on jack pine.

Progeny tests of spruce

One-parent progeny tests of selected phenotypes within seed production areas (SPA) have been started. Cone and seed data as well as germination capacity and growth performance are evaluated. Parent-progeny correlations will also be established. An early evaluation of one of the tests showed highly significant variation between progenies, for example, the average one-year height growth ranged from 41 to 71 mm with the tallest individual being 146 mm. The variation demonstrates the difference in combining ability of individual trees in an SPA and emphasizes the need to do selective rather than mechanical thinning when managing these areas.

The combining ability of plus trees established in clonal seed orchards is also being studied. Open-pollinated cones of black spruce were collected and cone and seed measurements will be correlated to parent and progeny growth. The seed from each ramet was germinated and grown separately so that the effect of different pollinators on the combining ability of a clone could be determined. The range of one-year seedling heights of the half-sib progenies, collected and grown from different ramets of the same clone (Table 1), illustrates the effect of clonal position in the orchard. (Rauter)

Seed source and production

Monitoring of seed yield and quality continued on a study plot of a white spruce seed production plantation (6203) at Orono. As yet no bumper crops have been recorded since 1967, when 52 kg of seed were collected from the 8 ha plantation. Since

TABLE 1 One-year seedling height, half-sib progenies from a black spruce clonal seed orchard

Clone	No. of half-sibs	Weighted average of one-year height growth (mm)	Range in heights for half-sibs within a clone (mm)
354	2	9.2	8.9 - 9.5
291	8	8.9	7.2 - 9.8
385	5	8.8	8.6 - 9.2
358	2	8.6	8.3 - 8.8
304	8	8.1	7.5 - 9.0
Control population	1	8.0	
290	8	7.9	7.4 - 8.4
288	8	7.6	7.2 - 8.4

1971, one third of the trees have produced cones. Seed weight studies on seed of 12 trees collected in 3 years showed a wide range in individual seed weights and a weak correlation of mean seed weights between years from each tree. Various provenance trials and seed quality assessments, undertaken in conjunction with the Petawawa Forest Experiment Station (CFS), continued. (Skeates)

White Russian source better

A Norway spruce (*Picea abies* (L.) Karst) study planted in Chapleau District in 1973 from stock supplied by Petawawa Forest Experiment Station was assessed in 1976. Overall survival and performance were superior on less exposed sites. White Russian sources appeared to have more application than coastal or central European sources in the southern boreal forest. Data are being analysed. (Skeates)

Initiation of flower primordia

In 1975, a cooperative research project with Dr Richard Pharis of the University of Calgary was undertaken to stimulate flowering of white spruce through gibberelin application. Counts of male and female flowers taken in the spring of 1976 indicated that gibberelins were effective

in promoting flowering. These data will be published with Dr Pharis at a later date. (Rauter)

Hybridization successes

In 1976, 11 intraspecific crosses and 19 interspecific crosses involving 14 species of spruce were attempted at Sault Ste. Marie using several provenances and clones. Ten interspecific crosses were successful. Although the number of hybrid seedlings is very low the consistent repeatability of the *Picea omorika* x *chihuahuana* through 4 years from 1973 is of interest. This cross had never been made before. A still more difficult cross, *P. rubens* x *chihuahuana*, has provided evidence of crossing since 1974. Unconfirmed seedlings of this cross and also for *P. rubens* x *glauca* have been obtained for 1976 crosses. *P. rubens* x *sitchensis* may also have been successful for the first time! Strongly heterotic seedlings of *P. omorika* x *sitchensis* have been obtained and are out-growing all other hybrid material. (Gordon)

Rooting of spruce cuttings

Clones of white and black spruce super seedlings selected in nurseries are being propagated by rooting cuttings. Young trees selected in plantations throughout the province also provide material for vegetative propagation.

The technique for rooting is constantly improving. Initially, environmental problems in the mist house hindered rooting success. The conditions have been modified and rooting percentages have been increasing yearly. White spruce has consistently rooted better than black, but rooting of the latter has improved considerably. Originally, the rooting medium was coarse sand. The resultant roots were very thick and brittle, and were extensively damaged when handled. Testing soil mixes showed that a finer, more supple root system develops when peat is added to the sand. Currently a 1:1 mix is used.

Transplant stock is, however, still a major problem, often resulting in high mortality. In order to overcome this problem, a rooting bed was established in the nursery at Maple so that cuttings could be rooted and grown undisturbed until they were

of field planting size. The rooting bed consisted of a fine sandy-loam soil. A wood frame was built around the bed and then covered with aluminum-painted plastic fixed on lath. The cuttings were placed directly into the soil and watered manually. When sampled in the fall, some cuttings had roots and most were still green and healthy. In the spring, the plastic will be removed and the cuttings grown until they are of outplanting size. (Rauter)

Soft pines

Activities concentrated on: *Pinus strobus* plus tree selection and progeny testing, field testing of *P. griffithii* McClelland x *strobus* F_1 and advanced hybrids, field testing of blister rust resistant *P. strobus* progenies, clonal propagation and testing of superior and blister rust resistant types, and introduction of exotics.

Progeny trials of selected blister rust resistant *P. strobus* trees showed very significant (up to 100%) variation in the height growth of progenies at the end of the 5th year. Observations made on the open-pollinated seeds and progenies showed large variation in seed weight and one-year seedling height. The above information indicated the importance of progeny testing for determining the combining ability of *P. strobus* plus trees. The significant seed weight/seedling height correlation (r=0.789) indicated the influence of seed weight on the nursery performance of the seedlings. (Zsuffa)

Hard pines

Jack pine phenotype studies continued. Seed weight heritabilities were calculated and showed a high degree of genetic control. The feasibility of parent tree selection for seed weight was concluded from these results (Zsuffa). Extensive stand testing of jack pine in northern Ontario will be undertaken to provide a means of identifying the best stands for seed collection areas. Climatic and edaphic variability and resulting population adaptation requires stand testing on a regional basis; for example, lower growth of some jack pine populations may be largely an adaptation to frequent late

spring frosts. Geographic variability must be related to this seasonal climatic factor. (Buchert)

Planting stock of *Pinus* (*sylvestris* x *densiflora*) x *nigra*, *P. rigida* x *taeda* and *P. rigida* x *radiata* was prepared for 5 experimantal field plantings. Observations made in earlier established trials indicated the value of some *P. sylvestris* and *P. nigra* varieties. (Zsuffa)

Provenance trials

Red pine provenance trials in the Lindsay and Blind River Districts established in 1956 were reassessed. In each case, differences between sources were small, but tree heights of the Kemptville source outperformed 11 other sources in each trial. Analyses of Scots pine provenance trials established in 1954 and 1956 suggested that although sampling distribution was limited, Lower Austrian and Baltic sources appear to have some application in northern and central Ontario while French and Austrian sources performed well in the south. Finnish sources were completely wiped out in Cambridge Township, south-east of Ottawa. (Skeates)

FAST GROWING SPECIES FOR INTENSIVE MANAGEMENT

Fast growing species, such as hybrid poplars, established near mills and managed intensively on the proper sites, can provide quickly a useful source of fibre. The testing and selection of clones to provide an ideal combination of rapid growth, frost and disease resistance, and desirable fibre characteristics are important here. Other uses of the plant material, for example as a protein source, are also being investigated. Equipment was designed and built for harvesting closely spaced plantations. Much of the work on fast growing species has centred on the poplars, but some work is now underway on larch.

Poplar farming

Clonal selection is of utmost significance in the mini-rotation concept of poplar management. Growth characteristics, stool longevity, disease resistance and the quality of biomass are under considerable genetic control and lend themselves to clonal selection. For example, the observed clonal variation in biomass production is as much as 400%, in wood specific gravity 50%, in moisture content 50%, and amino acids 100%. Very significant clonal variation was also observed in the biomass ratio of foliage to wood fibre, and in seasonal growth pattern. Biomass productivity plots of *Populus* x *euramericana* established in 1975 were remeasured. Those at Orono showed a 62% increase, due mainly to an improved fertilization prescription, while other areas showed a 15-20% decrease under unmodified cultural conditions. Production appeared related to foliar concentrations of potassium and phosphorus. Allometric equations are being developed which will allow prediction of oven-dry biomass yield from measurements easily obtained in plantations. Defoliation and seasonal cutting studies show clonal variation in sensitivity and these will be examined in more detail in 1977. (Zsuffa and Anderson)

Studies of protein quality, quantity and extraction technique show yields comparable to commercial utilization of many farm crops (Mr E. Chen*). Material from a preliminary

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leaf-ensilage study is being evaluated for *in vitro* digestibility at the University of Guelph. (Anderson)

New poplar harvester built

A mini-rotation poplar harvester was designed and built during the winter. The experimental machine consists of two distinct parts: a cutting head attached to the rear 3-point hitch of a large farm tractor, and a powerplant trailer, pulled behind by the tractor. The split unit has been designed for easy maneuverability and transportation. The cutting head is equipped with two 46-cm diameter, circular blade saws, hydraulically powered. Two meshing conveyor belts, about 1 m above the blades, are expected to grab the trees, hold them in place as they are being cut, and unload them behind the cutting head as the machine moves in a continuous forward motion. If this concept will work, a collecting trailer or a chipper may be added to the unit. Testing will begin in the spring of 1977. (Citro)

Promising hybrids created

Further efforts were made in breeding hybrid poplar clones. Numerous new crosses were realized between *P. deltoides* x *nigra*, *P. deltoides* x *balsamifera*, *P. deltoides* x *Maximowiczii* and promising hybrids were created for a variety of site conditions and management systems in southern and northern Ontario. Test plantations of hybrid progenies were established in eastern and northern Ontario. Observations made in clonal trials showed the superiority of several newly developed clones. Large scale propagation of these was initiated in special greenhouse and nursery systems. (Zsuffa)

Chemotaxonomy

Foliage polyphenols in young and old leaves of 14 pure poplar species and 12 hybrids were collected and analysed in June and August. Unique or discriminatory compounds were found in all pure species. Differences between clones of similar interspecific hybrids were primarily quantitative. This technique was also applied with good success to samples of native aspen from Thunder Bay. Results will facilitate field

mapping of natural clones.

Enzyme polymorphism of peroxidase and esterase in similar tissues of 10 pure species and 11 hybrids collected in July was examined in cooperation with Petawawa Forest Experiment Station. Many clonal variations were found which are being assessed in terms of their correlation with rooting ability and frost hardiness characteristics of the clones. (Anderson)

Rooting of aspens To study the nutritional factors involved in the rooting of aspen, a series of experiments was started to test the synergistic effect of combinations of hormones on aspen cuttings growing under optimum nutrient conditions. Cuttings of two clones of *Populus grandidentata* x *alba* (GA91 and GA44) were grown in pots in the greenhouse during the summer. Ammonium nitrate was applied at 150 ppm weekly for the first 3 weeks and then a complete nutrient solution was applied weekly. At planting, hormone combinations of IBA + NAA and IAA + GA at 10 and 100 ppm were added in solution (2 ml) to rubber tubes attached to the tops of the cuttings.

After 76 days, the highest percentage of rooting, the greatest number of roots per cutting, the greatest average root length, and the greatest amount of stem base swelling, occurred in cuttings treated with IBA + NAA at 10 ppm. Cuttings treated with IAA + GA showed less response than the controls. All results were significant at the 5% level. The results may have been affected by a disease among the cuttings which caused considerable mortality. This disease was not controlled by benlate or captan and a bacterium was suspected as the casual agency. (Leech)

In another study (Mrs S. Guha*), the effects of auxin and various phenolic activators on rooting of aspens are being evaluated.

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Site relations

The site requirements of poplar vary by species, but considerable clonal variation occurs even within each species group. In trials, at ages from 1 to 5 years, some clones of the same species origin varied in height growth by as much as 100%, while clones of different species origin differed by as much as 400%. Some clones grew relatively well on a number of sites, while others were very selective. Clonal selection has, therefore, a decisive influence on the success of plantation management. (Zsuffa)

Additional soil samples were taken and analysed this year to provide data on growth-site relationships over an increased range of sites. Preliminary findings indicate that the hybrid poplar clones grew best on sandy loam soil within a pH range of 6.2-7.4. No pattern could be established between growth of the various clones and organic matter, N, P. Ca, K and Mg content of the soil. (Sinclair)

Nutrient requirements

In the Owen Sound District, a study of the effects of fertilizers on 35 different clones of Euramerican poplars in a 6-year-old plantation on a sandy clay loam of pH 7.9 was continued. Trees fertilized with NPK (10-5-10) at 142 kg/ha annually for 3 years, increased in diameter on an average annually 9% more than controls. In the 4th year, increase over controls from NP (18-46-0) + KCl at 400 kg/ha was 13%. When this treatment was repeated in 1976, fertilized trees increased only 8% in diameter over controls. Some of these clones had reached their optimum foliar nutrient concentration while others were short of the optimum in K, Mg, and Ca. A detailed report is planned. (Leech)

Growth and yield

At 7 years from establishment, the best poplar varieties in plantation trials in southern Ontario grew to 12 m in height and to 17 cm in diameter at breast height, and produced a mean annual increment of 8 m^3/ha. At 12 years the best varieties were 17.5 m in height, 19 cm in diameter at breast

height, and produced a mean annual increment of 29 m^3/ha of total gross volume. (Zsuffa)

Recognition of larch's importance

A larch breeding program has recently been initiated as the importance of this fast-growing conifer for intensive management has been recognized. Initial efforts are on stand selection and testing of tamarack, which exhibits large variation in form and growth, and thus promises considerable and rapid genetic gains. Work started in eastern Ontario where seed from several areas was collected in the fall of 1976 and is being prepared for testing in 1977. In addition to the tamarack work, species trials of other larches will be established. (Rauter)

HARDWOOD FORESTS OF VARIOUS TYPES AND USES HARDWOOD FORESTS OF VARIOUS

The hardwood forest of southern Ontario is an important source of lumber, veneer and speciality products, such as maple sap. It is also an important recreational resource for the public and private owners. Studies involve unravelling the complexities of tolerant hardwood forest growth to improve the basis for management decisions, rehabilitating lowland and upland hardwood forests in southwestern Ontario to provide fibre and other products, and investigating the production of maple sap.

Dynamics of maple stands

Models developed to relate height growth response of sugar maple (*Acer saccharum*) advance growth to various intensities of partial cutting indicate similar sigmoidal relationships at both 11 and 19 years after cutting. Response rate tended to stabilize as overwood basal area approached zero. Currently, the effect of cutting intensity on structural recruitment in stands is being assessed. (Anderson)

Stocking of yellow birch regeneration

Intensive sampling of a 16-year-old regeneration experiment indicated that numbers of established yellow birch (*Betula alleghaniensis*) stems per hectare varied inversely with overwood basal area. Best stocking of 3700 stems/ha $\geq$ 2.5 cm (dbh) occurred on burned seedbeds under 9.2 m^2/ha of trees 10 cm (dbh) and over. All plots at densities less than 16 m^2/ha were considered to be fully stocked. Present work involves definition of cutting prescriptions for applying similar treatments on a management basis. (Anderson)

Silvicultural prescriptions

Silvicultural prescriptions for tolerant hardwood stands in the Algonquin Region are being developed from studies of quality, growth, stocking and structure. These studies are conducted in stands which have been disturbed by commercial logging or treated by thinning and improvement cuttings. (McLean)

Local white ash better

Hardwood seed from select sources was secured in cooperation with the Districts and a number of institutions in Canada,

USA and Europe for use in improving the production from upland sites in southern Ontario. A white ash (*Fraxinus americana*) progeny/provenance trial, comprising 36 families from 10 geographic locations in the USA and Canada, indicated that regular Ontario white ash stock, planted as controls, flushed out earlier in the season and generally gave a better first-year performance than a number of introduced sources. (Jaciw)

Damage to planted hardwoods

At Barrie, pre-establishment cultivation, combined with a single general spray of herbicide at planting time, appreciably enhanced the growth and vigour of most hardwood species. Planting in sod followed by repeated annual spot application of herbicides resulted in greater mortality, suppressed growth and more frequent girdling by rodents. Exceptionally heavy girdling by mice occurred for the first time in the 4-year-old hardwood plantation during the winter of 1975/76. (Jaciw)

Herbicide combinations effective

A recent planting site preparation trial in the Cambridge District involving 4 different herbicide treatments indicated that specific combinations of pre- and post-emergent herbicides are suitable for controlling both perennial ground cover and establishment of new weeds subsequent to cultivations. Treatments restricted to a single application of pre-emergent herbicides proved less successful. Further refinement of these techniques would obviate the need for continuation of costly post-planting interventions. The trial confirmed an urgent need for a modified tree planter, designed to better accommodate long-stemmed hardwood stock with a large root system, which is particularly vulnerable to toxic effects of some herbicide residues. (Jaciw)

Use of sewage effluent and fertilizers

The response in mixedwood plantings to irrigation with sanitized sewage effluent or to fertilization was more noticeable on fast-growing pioneer species, than on interplanted semi-tolerant or tolerant hardwoods. At Flesherton, fertilizer application during 4 out of 6 growing seasons

contributed to an appreciable improvement in vigour, height and particularly diameter growth of the covercrop poplar. Volume increased up to 40% in some varieties. At Fergus, decapitated, rooted poplar stock and unrooted 25-cm long cuttings, annually irrigated with sanitized sewage effluent, consistently showed better height growth than untreated controls. Improved growth of irrigated trees was generally more pronounced on unrooted cuttings than on rooted stock. (Jaciw)

Mixed conifer hardwood plantations

Several studies are in progress in jack pine, red pine and Scots pine (*Pinus sylvestris*) plantations interplanted or underplanted with various hardwoods. For example, data from a 28-year-old, mixed red pine-red oak plantation in Dufferin County Forest revealed that oak, though of smaller diameter, equalled or surpassed pine in average height by up to 2.6 m. The stem quality of oak is good. Oak showed somewhat better diameter increment following a release at age 23 years. This implies that crown tending is the prime factor in improving diameter growth of oak. In future studies, consideration will be given to closer spacing of oak, earlier crown tending and, perhaps, selection of superior stock for planting. (Stroempl)

Poplars and red ash for swamps

The Jackii poplar breeding program to develop trees for reforesting swamps of southern Ontario was continued. Efforts were made to induce rooting of severed flower branches of female eastern cottonwood (*Populus deltoides*) and balsam poplar (*Populus balsamifera*) prior to pollination. Earlier studies indicated that rooted branches produce better seed that unrooted branches. Pre-heating of the basal portion of each branch induced rooting but the upper portion of the branch that had been kept at below freezing temperatures did not develop healthy flowers when the whole branch was placed in the greenhouse. Ten red ash (*Fraxinus pennsylvanica*) timber selections out of a total of 14 phenotypes from 3

populations were successfully grafted in early June 1976. They will be established in 2 red ash seed orchards within 2 years. (Larsson)

Thinning silver maple in a swamp

The tenth-year remeasurements were made of a silver maple (*Acer saccharinum*) stand located in the Greenock swamp that had been mechanically and chemically thinned in 2 intensities in 1966. Observations revealed that chemical thinning when done properly gave as much release as mechanical thinning; intermediate crop trees of silver maple grew faster in height but less in diameter in thinned stands than in unthinned stands. The intermediate trees generally did not respond to thinning as well as the dominant and co-dominant trees in the stand. (Larsson)

Microtechnique to monitor sap production

A trial comparing maple sap yields and concentrations obtained by "micro" techniques, using hypodermic needles, with those of conventional spiles was concluded. Twenty two sugar maples in the 30- to 55-cm dbh range were sampled. Although the 2-minute micro samples gave consistently higher readings of sugar concentrations the relative patterns of sugar yields were comparable to those obtained with conventional spiles, particularly on days of good sap run. There is every indication that the micro technique could be used to advantage in monitoring maple sap concentrations in projects involving large numbers of trees. The 2-minute micro technique was less reliable as an indicator of volumetric sap yields. (Jaciw)

Increasing sap production

Chemical treatments involving hormones and fertilizers were later applied to some of the above trees in a preliminary trial to find practical methods of increasing crown growth of dominant and codominant sugar maple. Elsewhere, a replicated experiment was initiated this year to test the effect of NPK fertilizers on sap production. Foliar analyses were completed first to indicate specific fertilizer treatments. (Leech)

HARDWOOD FORESTS OF VARIOUS TYPES AND USES

Nectar production An experiment was designed and partially established in 1976 to test not only the ecological relationships between 6 tree, 5 shrub and 9 nectar-producing herbs but also to evaluate the honey-producing potential of a plantation with 3 floral layers, i.e. tree, shrub and herb layers, which would come into flower throughout the entire growing season. (Larsson)

Edible nuts A cooperative Hican breeding study was started with Mr Horace Troup of St. Catharines, Ontario. Some 109 flower clusters of 2 shagbark hickory (*Carya ovata*) cultivars were pollinated with 2 lots of pecan pollen (*Carya illinoensis*) from Brownwood, Texas, but only 2 mature nuts were harvested. The poor success may be attributed to technique and pollen incompatability. A library research appraisal was made (Jaciw) from several Russian texts on Korean pine (*Pinus koraiensis*) to determine where this pine can be grown in Ontario for nut and timber production. Two seed beds of this species were sown in the fall at Orono and Maple with the intention of outplanting seedlings in the spring of 1979. (Larsson)

MANAGING THE SPRUCE-FIR-ASPEN FOREST MANAGING THE SPRUCE-FIR-ASPEN FOR-

In northern Ontario, the spruce-fir-aspen forest is a major forest type. Studies undertaken by the Forest Research Branch concentrate on the upland sites, with particular emphasis currently on the quality and variation of aspen regeneration, the management of balsam fir and regeneration of the spruces.

Quality and variability of aspen regeneration

Two trials, in the Atikokan and Thunder Bay Districts, were established to both induce natural suckering of aspen (*Populus tremuloides*) and to study the relationships between natural regeneration by root suckering and the timing and intensity of mechanical scarification following harvesting of the original stand. Both trials included spring and fall applications of light and heavy scarification in the year immediately after harvesting. Preliminary occular estimates indicated that substantial differences in aspen densities can be obtained by manipulating these two factors. A further trial next year combined with continuous monitoring of the results will evolve silvicultural recommendations for improved management of this species.

Past management practices have been generally aimed at controlling or inhibiting aspen in favour of conifers. The success of control treatments such as intensive mechanical scarification or herbicide application on established aspen regeneration to permit stand conversion to conifers has generally been short term. Re-suckering of aspen or the recovery and survival of the damaged stems over the treated areas have resulted in aspen overstories of unknown quality. With the current enlightened interest in the real value of this specie, studies were started this year to investigate the long term advantages and disadvantages of these management practices. Stand and wood quality considerations of growth rates, yields and internal stem defectiveness are included in the study. Defect aspects are being studied in close cooperation with the CFS's Great Lakes Forest Research Centre. (Kemperman)

Clonal management

Literature reviews and past research have confirmed that the aspen clone, not the individual aspen tree, is the key element in the sound management of this species. Studies were continued this year to acquire an improved understanding of the clonal nature of regenerating aspen stands. In 1975 and 1976 some 50 separate identifiable clones have been thoroughly examined for differences in soil and site characteristics, in growth rates, in external features and in defect resistance. Here, too, the pathological aspects are being studied in close cooperation with the Great Lakes Forest Research Centre. (Kemperman)

Balsam fir cone crops

Past observations of flowering, cone and seed production in balsam fir (*Abies balsamea*) at one locality in northern Ontario have indicated a 2-year cycle (odd years since 1969) of cone periodicity. The year 1976 was not a seed year although there was limited flowering on some of the trees. The lack of seed production delayed the continuance of balsam fir seed quality and germination studies. This study will continue in 1977. (Lehela)

Herbicides release fir

Field investigations to determine the magnitude and duration of growth response of balsam fir after altering the composition and density of mixedwood stands with phenoxy herbicides were continued in 1976 near Manitouwadge. Analysis of growth data for 3 areas experimentally treated with phenoxy herbicides in 1955 and 1957 confirmed that spraying is a sound management tool by which fibre yield can be improved. Twenty years after treatment, for example, the net total volume gain of trees which were up to 3 m tall at the time of spraying was 160% of that of the average control area tree.

Examination of stand density and composition suggested that stand characteristics influence the gain in growth less than does the strength of the spray solution. The greatest net gain in volume growth was obtained when 1.7 kg/ha of 2,4,5-T or 3.8% spray solution had been applied to a mixedwood forest.

Absence of decline in volume production indicated that only one spray application is necessary. This work will continue until the shapes and levels of predicted portions of yield curves can be drawn to match actual growth. (Lehela)

Balsam fir succession

Field investigations started near Thunder Bay this year to determine the extent of the balsam fir resource resulting from current (post 1960) mechanical harvesting methods. The purpose is to compare the population dynamics of balsam fir resulting from current mechanical harvesting techniques with those resulting from early (pre 1960) mechanical harvesting methods which are already documented. If both population dynamics are similar, it will expedite our ability to predict more accurately the future status of the balsam fir resource. Analysis of successional trends will also help to find essential modifications in logging to take advantage of residual balsam and its regeneration potential. Collectively all the information gained from this investigation thus far shows that balsam fir can no longer be ignored as a potential source of fibre. (Lehela)

Moisture studies on spruce cutovers

In cooperation with the Great Lakes Paper Co. Ltd., moisture regimes on upland black spruce sites were measured from June through to October (1976). Sites on which monitoring stations were located were scheduled for cutting by a) strip cutting and b) clear cutting. Moisture regime values (by electrical resistance) will again be measured in 1977 and should provide comparative information on soil moisture conditions on forest sites cut by contrasting methods. (McClain)

Production and planting of spruce stock

Research into nursery production of white spruce and extension of the planting season for black spruce has been noted under Enhancing Stock Production and Performance.

SITE AND GROWTH RELATIONS SITE AND GROWTH RELATIONS SITE AND GROWTH RELA-

Assessments of soil moisture conditions and the nutrient status of a site are needed, for example, in determining the suitability of planting conditions. We also need to know whether a particular species, through its root development and uptake of water and nutrients, could grow adequately if planted on a certain site. Studies of biomass, productivity, growth, nutrition and nutrient cycling provide an excellent base for projecting nutrient status and turnover, as well as fertility demands of stands over a rotation. These can lead to further studies of nutrient loss and site stability, which are important in cooler climates of the boreal forest.

Evaluating SMC from FWI

This is the second year of a study to determine the relationship between fire weather index (FWI) and soil moisture content (SMC). The same factors influence both FWI and SMC, namely precipitation into and the evaporation out of the site. Since FWI is determined daily at many locations across the province during the fire season (hence, growing season) and these records are kept for past years, their use could be extended for silvicultural purposes as well as for forest protection. Data collection was continued in 1976 at two of the Algonquin Region sites studied in 1975 and was extended to two new sites in Central Region. These data are being analysed. (Pierpoint)

Field guides prepared

Work continued on developing a guide to the field recognition of soil moisture regime, for use by management staff. The manuscript for the guide "Soil texture and its field identification", developed in cooperation with staff of the Ontario Land Inventory, was completed and is in press. (Pierpoint)

Rapid techniques to assess planting sites

To meet the need for rapid on-site assessment of prospective planting sites, studies were started in 1974 to select and develop methods of foliar analysis suited to the field by modifying the existing rapid-test methods for tissue and soil. During 1976, tests for N, P, K, Mg, Mn and Mo were studied and

some progress made towards simplifying them for field use. The extraction of N received priority, since total plant N is a good indication of available soil N for which there is no reliable test. In the method studied, the time required for the preparation of samples and wet ashing with H_2SO_4 and H_2O_2 was from 30 to 40 minutes, while the test required 1 to 2 minutes. Analyses of the foliage of 5 tree species by this method were almost identical to those obtained from the standard Kjeldahl method. However, a test for NO_3-N was unsuccessful due to low foliar concentration of NO_3 and interference of organic compounds. The wet ash samples prepared for total N could also be used for P determination. But it may be simpler to use the Morgan Extraction Solution (sodium acetate + acetic acid) for P and for K, Ca and Mg, even though as yet this gives only rough estimates of nutrient concentrations in tissue.

The continuing objective of the present study is to select test reagents which will be sensitive enough and can be impregnated into test paper. Some success was obtained in this way with Nessler's Reagent (KI + $HgCl_2$) for total N; 0.5% ammonium molybdate + 0.06% stannous chloride for P, dipicrylamine + sodium bicarbonate and cobalt nitrite reagent for K; and titan yellow + NaOH for Mg. (Leech and Kim)

Relation of stock's foliar nutrition to site

A study of the use of foliar analysis to aid in selecting planting sites for red pine continued. Foliar samples and height measurements were made of 3+0 stock outplanted in 1974 by the wedge method on 6 level sites in Huronia District. On all sites there was a direct relation between total soil N and the change in foliar N; and between soil pH and change in foliar Ca. (Leech)

Nutrient sequence important

In fertilizer studies of jack pine, the age and stocking of the stand treated was found to determine which sequence of nutrients should be added in fertilizers to give the greatest growth response of crop trees and thinning out of unthrifty

trees. A new study has been initiated in the Blind River District to determine the best sequence of fertilizers and time of application to increase cone crops of young white spruce, red pine and jack pine. (Leech)

Poor vertical rooting may contribute to suppression

Analyses of root and stem development of red pine undergoing suppression in a 35-year-old plantation indicated that inadequate vertical rooting may have been an important factor contributing to suppression. Suppressed trees had no or very few deep vertical roots whereas codominant trees had several such roots. All deep vertical roots in the loamy sand studied tapped moisture-holding layers via old root channels. The development of deep vertical roots may be a matter of chance--some trees have no roots which encounter the favourable conditions found in old root channels for rapid downward extension of the root system. Height growth of the suppressed trees was less than that of codominants right from planting and may have influenced root development. (Fayle)

Productivity and nutrient cycling in spruce forests

Work continues on the dynamics of the nutrient cycle in spruce forests, particularly on inputs from precipitation and nutrient transfer in the soil profile. Monitoring has commenced but further installations are required. In the biomass studies, preliminary assessment of data from above-ground biomass of mature, fully stocked spruce forests on 4 moisture sites showed that the greatest biomass occurred on moist sites (Table 2). A data summary of biomass, productivity and nutrient capital of north temperate spruce forests, completed as part of the Woodlands Working Group of the International Biological Program, will be published in 1977. (Gordon)

Extension of site regions

Within Ontario, Site Regions can be used to make adjustments when we wish to apply in one region knowledge and experience obtained in another one. Work published for the Maritime

provinces, Manitoba, Saskatchewan and British Columbia is being studied to extend the site region concept beyond Ontario. Similarly, a first attempt was made to describe site regions for three Lake States (see New Publications, 1). Contacts are maintained with researchers in Europe and Asia for similar purposes. For the next five years, leadership will again be provided for Working Group "Site Classification" of the International Union of Forestry Research Organizations. (Burger)

TABLE 2 Above-ground biomass of mature, fully stocked spruce forests on 4 sites, in 1000 kg/ha

	Dry	Fresh	Moist	Wet
Foliage	4.73	12.99	10.38	5.62
Cones	.05	.03	.28	.11
Branches	6.77	20.99	32.55	11.46
Dead branches	1.92	5.74	9.71	3.83
Boles and bark	31.76	102.44	135.89	82.26
Total	45.23	142.19	188.81	103.28

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Knowledge of the growth potential of conifer plantations and managed hardwood stands helps the forest manager to decide the best treatment for each forest condition. Studies to date have concentrated on obtaining information for red pine and hardwoods in southern Ontario. The broad field of obtaining, interpreting and using information on the forest resource is also being examined.

Red pine volume growth tables

Plantations of red pine, either pure or in mixture with white pine, have been thinned to various levels over a 25-year period. Permanent sample plot data from these stands have been combined in the preparation of volume growth tables for use on sites generally planted to red pine.

In cooperation with District staff, records of individual plots showing the best development for poles have been selected to determine thinning schedules applicable to younger pine stands.

For comparison with pure pine yields on the same site, a young plantation of mixed red pine and red oak has been assessed for growth and other silvicultural considerations. (Beckwith)

Hardwood growth

Volume and quality growth data available from managed hardwood stands of southern Ontario have been reviewed and a program of experimental cutting has been laid out starting with the Central Region.

Work continued on a maple-basswood (*Tilia americana*) stand in Bancroft District which had received a variety of silvicultural treatments in 1965. The 1-year growth in this stand averaged 0.73 m^2/ha in basal area and 84 m^3/ha in total volume. (Beckwith)

Instrument check

The accuracy of measurements made on standing trees using a Wheeler Dendrometer and a Telerelascope was checked against cut tree scales of merchantable volume. With different operators, both instruments resulted in acceptable estimates of volume over a range of diameter classes. The Wheeler

tended to over-estimate and the Telerelascope to under-estimate the actual volumes by similar amounts. (Beckwith)

Systems information

Since July, 1970, efforts have been made to formulate a Management Information System for Timber Sales Branch. These efforts have been focussed on various aspects of how to obtain information on forest resources, how to interpret it and how to use it. Among the following pursued in 1976 were: analysis of stand records for improving inventory and cruise estimates; modeling of stands for projecting production, updating inventory and improving planning; compilation of quality class cruises in Algonquin Park for the Algonquin Forest Authority; the application of digitized maps to record keeping and planning; and analysis of animal records and modeling of populations. (Raymond)